FINAL REPORT

Acid Mine Drainage Control - Feasibility Study
Cooke City, Montana

Submitted to

the

Department of Natural Resources and Conservation

By

Montana Bureau of Mines and Geology

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Mill Area

Introduction

The mill processed ore from the McLaren mine and just east of Cooke City, was between the Beartooth highway and Soda Butte Creek. The tailings pond begins about 400 feet southwest of the old mill site, and is roughly elliptical, having axial dimensions of about 850 and 500 feet. The tailings pond is over the old Soda Butte Creek stream channel; the present stream course is the result of diverting the creek around the north side of the tailings pile. When the Bear Creek Mining Company purchased the McLaren mine property, the mill site came with the mine in a "package" transaction. Bear Creek leveled the tailings material and covered it with roughly 1.5 to 3.0 feet of alluvial sand and gravel in the 1960's.

Geology

The mill area is underlain by moraine deposits of Pleistocene age (Elliott, 1973) covered with a thin veneer of Recent stream deposits. Bedrock consists of coarse-grained granite and fine-grained diorite. The diorite is believed to be a small dike, of Tertiary age, which intruded the granite. The diorite was encountered in drill hole number 24B (figure 13 and appendix B), which penetrated the thickest section of gravel. The 47.5 feet of gravel below the tailings and above bedrock may be related to the lesser resistance of the nongranitic igneous rocks to chemical weathering (Holmes, 1960, p. 393-400), or this hole may be located closer to the part of the valley that was deepest at the time when glacial aggradation (valley filling) began. Regardless of the origin of the gravel-filled depression, the thickness of the gravel at this location will place serious engineering constraints upon any attempts to dam the tailings and gravel to prevent ground water within the tailings from passing through the gravel or to flood the tailings pond.

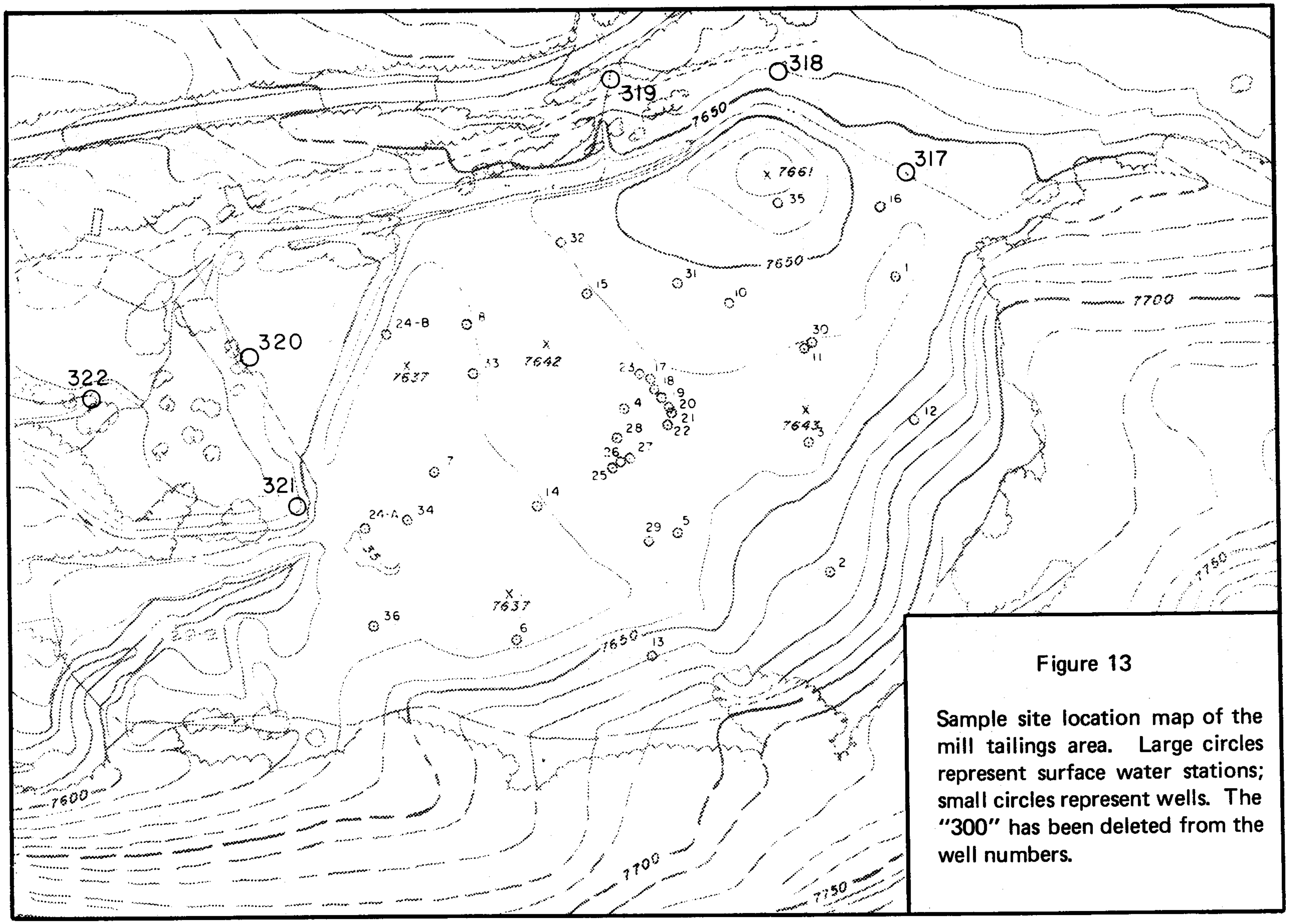

Figure 13

Sample site location map of the mill tailings area. Large circles represent surface water stations; small circles represent wells. The "300" has been deleted from the well numbers.

Tailings

The thickness of the tailings is known to range from about 0.1 to 31.7 feet. The tailings (appendix D) consist of phyllosilicates (clays), tectosilicates (predominantly feldspars and quartz), sulfides (mostly pyrite), iron oxides (magnetite, goethite, and ferric hydroxide), and calcium salts (gypsum and calcite). Most of the material is coarser than 325 mesh (seive opening 44 microns or 0.044 millimeter). Chemical analyses were run on samples from nine of the holes drilled during 1975 to obtain a range for the metal values and chemical constituents that affect the smelting costs (table 9). Shortly after these samples were submitted to the Bureau laboratory, the Bear Creek Mining Company provided auger-location (figure 14) and polygonal ore-reserve maps and a tabular summary of their assay of the mine tailings. The ore-reserve map is fairly large. The maps and table are on file with the Montana Bureau of Mines and Geology. The assay values and tonnage information were used to calculate weight-corrected averages for the tailings as shown in table 10. The value of the tailings at current (December 1975) metal prices is: (1) gold = $2,975,000; (2) silver = $287,400; (3)

Table 9.–Chemical analyses of Montana Bureau of Mines and Geology drill holes, McLaren mill site.

Drill	Ounces per ton		Weight percent						
Hole No.	Au	Ag	Cu	Pb	Zn	SiO_2	S	Fe	Al_2O_3
22	0.050	0.18	0.349	0.150	0.100	28.22	14.14	26.96	21.84
23	0.100	0.16	0.336	0.200	0.075	33.20	11.07	22.82	27.54
25	0.070	1.42	0.246	0.175	0.012	29.36	11.24	24.60	20.90
28	0.090	0.26	0.362	0.125	0.075	26.12	14.56	27.94	20.42
29	0.120	0.24	0.284	0.100	0.100	28.22	13.49	25.19	20.01
30	0.280	0.32	0.297	0.150	0.025	28.42	14.32	27.35	20.45
31	0.070	0.05	0.181	0.075	0.025	34.14	3.38	22.82	20.24
33	0.015	0.24	0.336	0.150	0.025	28.46	11.57	25.19	20.31
34	0.180	0.34	0.427	0.125	0.037	29.46	12.91	24.50	22.00
Average	.108	.357	.313	.139	.053	29.51	11.85	25.26	21.63

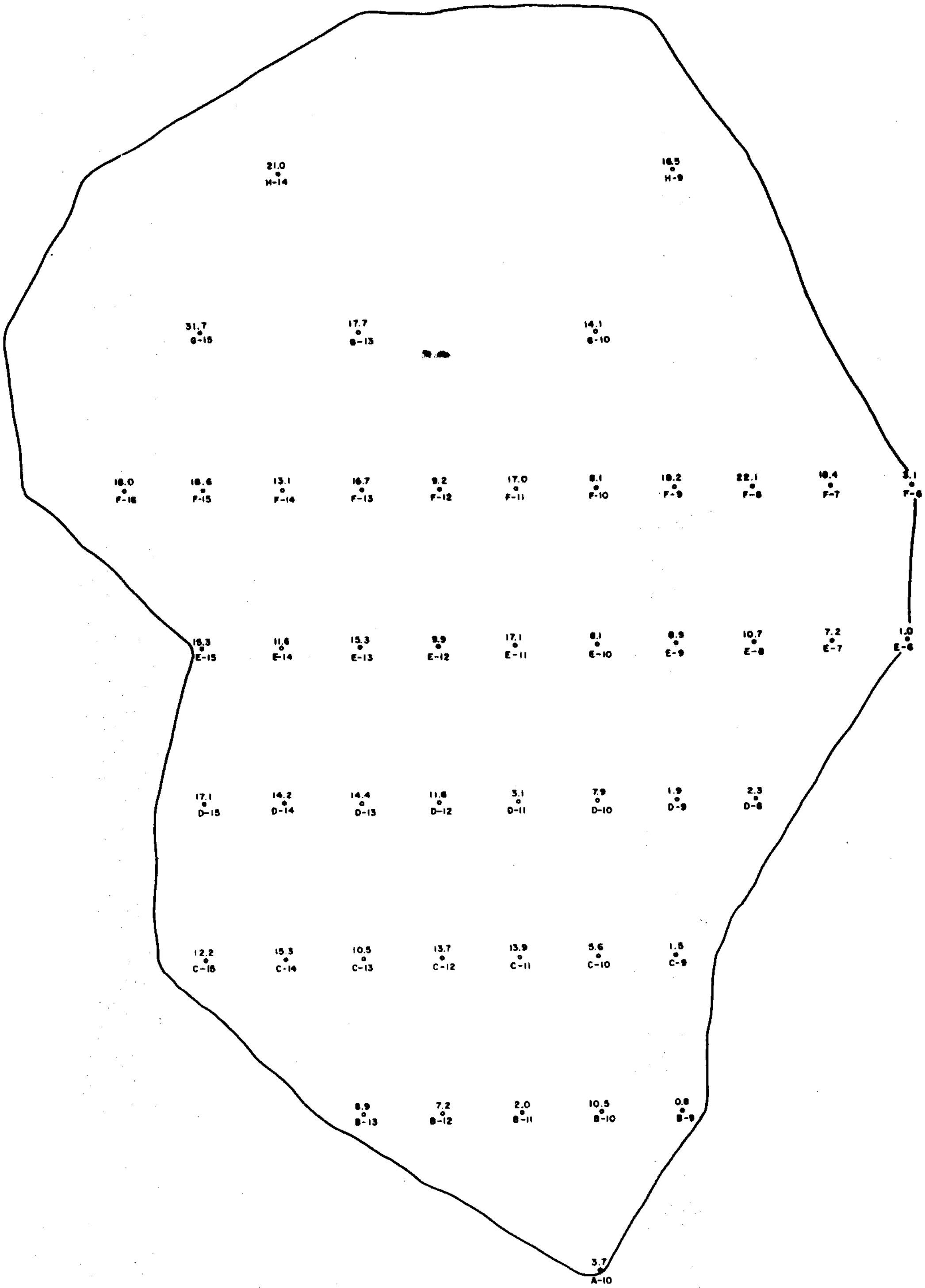

Figure 14.—Location of Bear Creek Mining Company's auger holes at the mill site.

Table 10.—Tailing tonnage and metal values, McLaren mill site.
(Data provided by Bear Creek Mining Company)

Hole No.	Depth (feet)	Tonnage (20 ft^3/ton)	$T/\Sigma T=f$ $\times 10^{-3}$	Ag (oz)	Ag x f	Au (oz)	Au x f	Cu %	Cu x f
A-10	3.7	577	2.82	0.20	0.56	0.155	0.437	0.44	1.24
B-9	0.8	1,382	6.75	0.34	2.30	0.165	1.114	0.15	1.01
B-10	10.5	2,625	12.80	0.57	7.30	0.130	1.664	0.39	4.99
B-11	2.0	501	2.45	0.49	1.20	0.090	0.221	0.15	0.37
B-12	7.2	1,843	9.00	0.77	6.93	0.115	1.035	0.10	0.90
B-13	8.9	2,122	10.40	0.24	2.50	0.080	0.832	0.39	4.06
C-9	1.5	398	1.94	0.31	0.60	0.170	0.330	0.34	0.66
C-10	5.6	1,400	6.83	1.21	8.26	0.130	0.888	0.48	3.28
C-11	13.9	3,475	17.00	0.32	5.44	0.200	3.400	0.29	4.93
C-12	13.7	3,425	16.70	0.56	9.35	0.125	2.088	0.29	4.84
C-13	10.5	2,625	12.81	0.47	6.02	0.110	1.409	0.24	3.07
C-14	15.3	4,192	20.46	0.32	6.55	0.120	2.455	0.34	6.96
C-15	12.2	2,840	13.86	0.40	5.54	0.070	0.970	0.34	4.71
D-8	2.3	633	3.09	0.22	0.68	0.125	0.386	0.24	0.74
D-9	1.9	475	2.32	0.20	0.46	0.080	0.186	0.24	0.56
D-10	7.9	1,975	9.64	0.40	3.86	0.070	0.675	0.29	2.80
D-11	3.1	475	2.32	0.10	0.23	0.160	0.371	0.15	0.35
D-12	11.6	2,900	14.16	0.41	5.81	0.155	2.195	0.48	6.80
D-13	14.4	3,600	17.57	0.33	5.80	0.090	1.581	0.29	5.10
D-14	14.2	3.550	17.33	0.35	6.07	0.100	1.733	0.24	4.16
D-15	17.1	4,555	22.23	0.43	9.56	0.110	2.445	0.39	8.67
E-6	1.0	84	0.41	0.32	0.13	0.080	0.033	0.29	0.12
E-7	7.2	1,802	8.80	0.26	2.29	0.140	1.232	0.39	3.43
E-8	10.7	2,675	13.06	0.28	3.66	0.120	1.567	0.44	5.75
E-9	8.9	2,225	10.86	0.29	3.15	0.170	1.846	0.48	5.21
E-10	8.1	2,025	9.88	0.30	2.96	0.120	1.186	0.39	3.85
E-11	17.1	4,275	20.87	0.43	8.97	0.100	2.087	0.29	6.05
E-12	9.9	2,475	12.08	0.30	3.62	0.100	1.208	0.34	4.11
E-13	15.3	3,825	18.67	0.10	1.87	0.110	2.054	0.39	7.28
E-14	11.6	2,900	14.16	0.10	1.42	0.110	1.558	0.39	2.52
E-15	15.3	3,500	17.08	0.11	1.88	0.095	1.623	0.39	6.66
F-6	3.1	310	1.51	0.32	0.48	0.080	0.121	0.29	0.44
F-7	18.4	6,395	31.22	0.26	8.12	0.100	3.122	0.39	12.18
F-8	22.1	8,071	39.40	0.11	4.33	0.110	4.334	0.34	13.40
F-9	18.2	5,132	25.05	0.18	4.51	0.100	2.505	0.34	8.52
F-10	8.1	2,025	9.88	0.18	1.78	0.090	0.889	0.39	3.85
F-11	17.0	4,726	23.07	0.33	7.61	0.115	2.653	0.39	9.00
F-12	9.2	2,558	12.49	0.26	3.25	0.120	1.499	0.34	4.25
F-13	16.7	4,175	20.38	0.34	6.93	0.080	1.630	0.39	7.95
F-14	13.1	3,505	17.11	0.50	8.56	0.100	1.711	0.39	6.67
F-15	18.6	4,650	22.70	0.32	7.26	0.080	1.816	0.34	7.72
F-16	18.0	6,926	33.81	0.34	11.50	0.080	2.705	0.44	14.88
G-10	14.1	11,562	56.44	0.36	20.32	0.080	4.515	0.39	22.01
G-13	17.7	12,376	60.41	0.32	19.33	0.100	6.041	0.39	23.56
G-15	31.7 (?)	22,786	111.23	0.35	38.93	0.092	10.233	0.39	43.38
H-9	16.5	17,166	83.79	0.30	25.14	0.085	7.122	0.44	36.87
H-14	21.0	21,142	103.20	0.30	30.96	0.100	10.320	0.58	59.86
	Σ=546.9	Σ=204,859			Σ=323.98		Σ=102.025		Σ=389.720

Weight corrected average values: Gold, 0.103 oz./ton
Silver, 0.324 oz./ton
Copper, 0.390 percent

copper = $1,006,700, thus the sum of these three metal values in the tailings is 4.269 million dollars.

Examination of the auger cuttings and split-spoon cores indicated two significant zones of sulfide oxidation within the tailings. An upper zone of oxidation showed in all holes as red iron stain. Additional stringers of oxidized material, seemingly associated with sandy layers, were noted to a depth of 10 feet. A second zone of oxidation, at the base of the tailings, was erratic. It consists of ferric iron cementing material which, with some of the fines from the tailings, has filled the open space in the underlying sand and gravel. The cementing iron is principally goethite and one or more x-ray amorphous phases. Because goethite ($FeO(OH)$) commonly forms by the dehydration of ferric hydroxide [$Fe(OH)_3$], ferric hydroxide is believed to be the predominant x-ray amorphous phase. Thermodynamic calculations suggest that before the tailings waters become saturated with respect to ferric hydroxide, jarosite [$KFe_3(SO_4)_2(OH)_6$] saturation is reached.